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The Identification of Geothermal with Geographic Information System and Remote Sensing in Distric of Dolok Marawa

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Abstract. The potency of the Indonesian geothermal resources able to supply 40% of world's demand on the geothermal resources. These resources are spread over 251 locations at 33 provinces having the total potential energy of 27.149 MW. One of these geothermal resources is Tinggi Raja located at Distric of Dolok Marawa, Simalungun Regency, North Sumatera 449385 E – 473025 E and 324105 N - 349545 N. This paper reports the study on mapping of the prospect of geothermal resource area by utilizing a remote sensing. The remote sensing consisted of Landsat 8 OLI which was published on February 8th 2015 and June 29th 2015 with Path 129 Row 58 as input data for ENVI 4.7 and ArcGIS 10 as mapping tools. Calculated land surface temperature (LST) was essential for mapping and calculating a geothermal resources. In this study, land surface temperature was used as the Thermal Infrared images obtained from the thermal infrared remote sensor. The highest achieved LST was 310.889587 K. The obtained LST distribution indicated the location of the geothermal potential.

INTRODUCTION

The world energy demand increases tremendously related with the high economic growth of several developed countries. It is inversely proportional to the energy supply which is limited for non-renewable energy resources. One of renewable energy resources is a geothermal energy which is a clean and friendly energy alternative and also renewable. The potential of geothermal energy in Indonesia covered 40% of the world's, spread over 251 locations at 33 provinces with a total potential energy of 27.140 MW which is equivalent to 219 Billion Barrels of oil equivalent [1]. The utilization of the geothermal install capacity is 1.194 MW or 4% of all the existing potential resources. One of Indonesian island is Sumatra island that location at the confluence of two tectonic plates, the Eurasian Plate and Indo-Australian plate, causing frequent earthquakes and possess a potential geothermal areas. Sumatra Island has geothermal potential sources up to 13.470 MW which is the biggest potential compared to other islands [2]. One of area that potential of geothermal is Distric of Dolok Marawa on 02°36'- 03°18' North latitude and 98°32' - 99°35' East longitude obviously supported by the existence of the hot springs [3].

Geotermal resources located inside the Earth and difficult terrain caused challenging on the exploitation of the energy resources. Therefore, we need new technology such as a remote sensing technology which capable to identify location of geothermal potential [3, 4]. The utilization of a remote sensing technology is to obtain the location the exploitation of geothermal. The imagery satellite such as Landsat sattelite use to search the location of the geothermal energy provided the thermal infrared images. The thermal infrared images are measured using a thermal infrares remote sensing (TIRS) method. TIRS method is an effective technique to overcome these limitations in data distributions because active geothermal fields accompany surface manifestations of the transport of heat and mass through the crust such as volcanoes, hot springs, mud pots and fumaroles, which can be distinguished as thermal high anomalies in the Land Surface Temperature (LST). TIR has great potential for cost-effective geothermal resource exploration [4]. This study utilize TIRS of Landsat 8 OLI (path 058 and row 129)

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which able to predict the energy potential for several years in the future. Similar studies using a remote sensing were conducted for geothermal prospect in the Patuha area, West Java [5], Silali geothermal prospect in Kenya [6], hot springs in Nevada, USA [7], and in Hokkaido, Northern Japan [8]. Therefore, in this study on the geothermal potential was focus in the location of research interest of Dolok Marawa area by using a remote sensing method.

GEOGRAPHIC INFORMATION SYSTEM AND REMOTE SENSING METHOD

Remote sensing is an art and science to get the information about an object, area or phenomenon. It obtains analysis of data simply with using tools without contact with the object, area or phenomenon [9]. Remote sensing uses spatial data such as satellite images, i.e. Landsat [10] such as Landsat 8 OLI. The satellite images of Landsat 8 has a features of 705 km wides from the earth's surface, and a scanning area of measurement 185 km × 185 km. NASA Landsat 8 OLI targeting a mission over 5 years of operation (OLI sensor designed for 5 years and TIRS sensor designed for 3 years). Landsat 8 satellite have 2 sensors, Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). Landsat 8 satellite have 11 numbers of channels includes 9 channels (bands 1-9) for OLI and 2 channels (band 10 and 11) for TIRS [10]. TIRS can be applied to identify geothermal potential by finding the values of Land surface temperatures (LST) or T. The LST are found by using corrected TIRS from band 10. The correction is radiometric correction (digital converting number to radiance) calculation with the formula using LMIN and LMAX spectral radiance scaling factors as described in Eq. 1 [11].

$$L_{\lambda} = \left(\frac{LMAX_{\lambda} - LMIN_{\lambda}}{QCAL_{MAX} - CAL_{MIN}} \right) \times \left(QCAL - QCAL_{\min} \right) + LMIN_{\lambda} \tag{1}$$

where:
L_{λ} = The cell value as radiance
$QCAL$ = Digital number
$LMIN_{\lambda}$ = Spectral radiance scales to $QCAL_{MIN}$
$LMAX_{\lambda}$ = Spectral radiance scales to $QCAL_{MAX}$
$QCAL_{MIN}$ = The minimum quantized calibrated pixel value
$QCAL_{MAX}$ = The maximum quantized calibrated pixel value

After converting the digital number to radiance, then the radiance values is converted into the temperature unit, such as Kelvin using Eq. (2) [11].

$$T = \frac{K_2}{\ln\left(\frac{K1}{L\lambda} + 1 \right)} \tag{2}$$

where:
T = Temperature in Kelvin
L_{λ} = The cell value as radiance
K_1 = Constanta 1, 1321.08
K_2 = Constanta 2, 774.89

If necessary, the temperature in Kelvin is converted into Celsius using formula in Eq. (3).

$$T(C) = T(K) - 273 \tag{3}$$

where:
$T(K)$ = Temperature (Kelvin)
$T(C)$ = Temperature (Celcius)

Briefly, the methodology on determining the geothermal potential was conducted by calculating the estimates temperatures of the LST values on the respected research location research by obtaining the thermal infrared image.

Research Location

The research area was the geothermal Tinggi Raja's village, Distric of Dolok Merawa located on geographic coordinates between 449385 E – 473025 E and 324105 N - 349545 N.

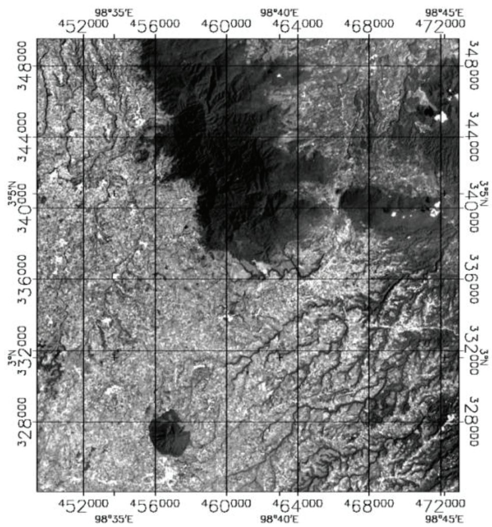


FIGURE 1. Research Location

Tools, Data and Procedure

The mapping tools used to find LST value and NDVI value were represented in Table 1. The data used for this study was depicted in Table 2. Procedure on calculating the estimates temperature to find geothermal resources as follows: by using the Land surface temperature formula by inserting the thermal infrared image from thermal infrared remote sensor (TIRS) of Landsat 8 OLI (Path 129 and Row 58). Thermal infrared image was cropped in the study area (Distric of Dolok Marawa), and then correction was calculated by using correction radiometric formula. Finally, land surface temperature (Kelvin) values obtained by inserting the radiometric values using Eq. (2) and converting the LST value in kelvin to celcius. Futhermore, LST values was classified from low to highest temperature to evaluate the geothermal prospect.

TABLE 1. Table of tool research

No	Name	Spesification	Total
1.	Laptop	Intel core i3	1
	1. ArcGIS 10.0	HDD 500 MB	
	2. ENVI 5.0	RAM 2GB	

TABLE 2 . Research data

No	Name	Spesification	Total
1.	Landsat 8 OLI path 129 row 058	Band 10 Thermal Infrared – 100 m	1
2.	Administration boundaries	Distric Simalungun	1

RESULTS AND DISCUSIONS

Figure 2a and b show the result of the radiometric correction and corresponding LST values for the received data on February 8th 2015. While Fig. 2c and d show the result of the radiometric correction and corresponding LST values for the received data on June 29th 2015. The result of radiometric correction at different color where black indicating lowest values to white indicating the highest value. The maximum value of LST for the received data on February 8th 2015 was 36.303497 °C and minimum value was 2.720490 °C. The maximum value of LST for the received data on June 29th 2015 was 37.889587 °C and minimum value was 18.476654 °C. It was observed that the temperature was increased, as shown in Fig. 2.a-d.

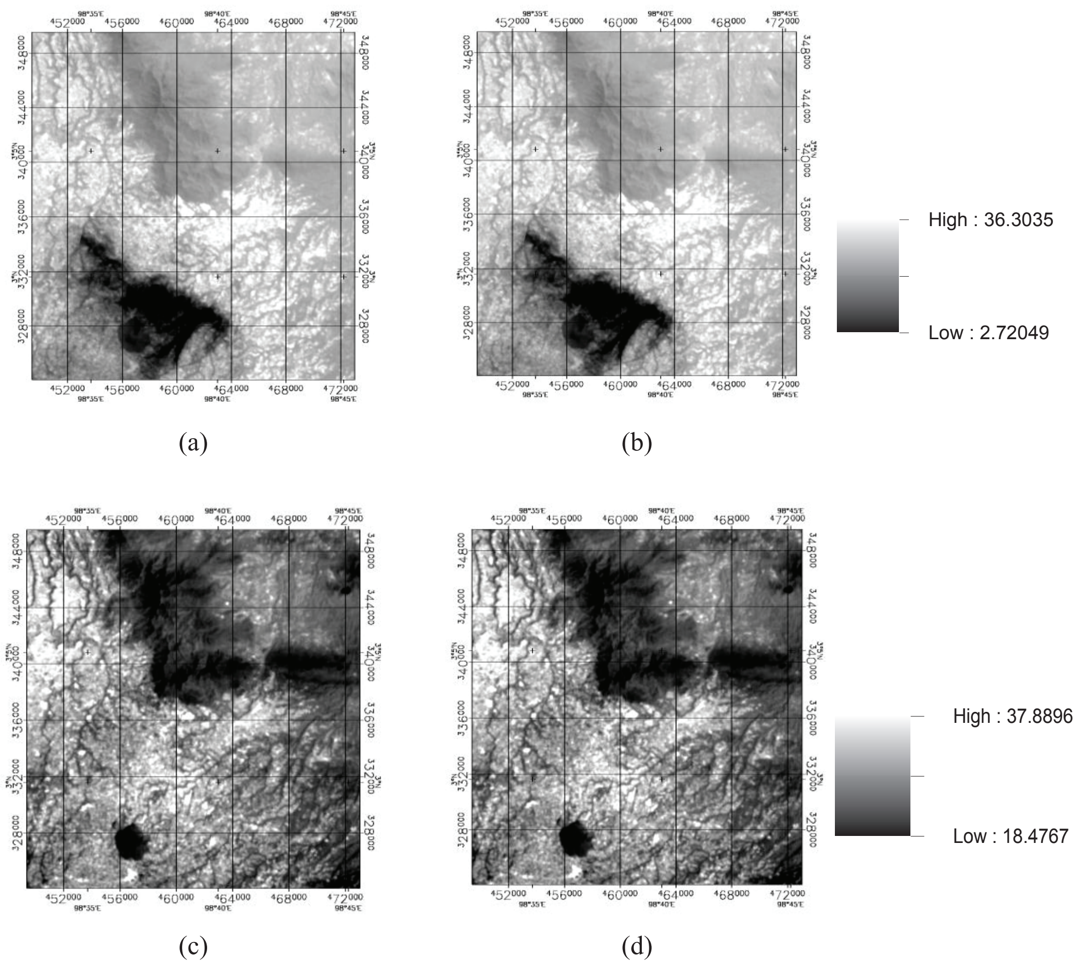


FIGURE 2. LST of the Distric Dolok Marawa (a), (b), (c) and (d)

The highest value of LST was found at coordinates 450285.00 E, 341895.00N meters with LST value of 37.738098°C. This location observation point most probably indicating the potential of geothermal energy. It is also possible represent the LST values both vertically and horizontallyhe includes the highest comparison value of the constant k (1 / λ), as shown in Fig 3.

Futhermore, the LST result at June 29th 2015 was classified into some categories. The categories were low, modeare, high and very high. The minimum temperature (< 20 °C) has identificated as black color, for temperature claffication of 20 – 25 °C identificated as ash gray color, temperature claffication of 25 – 30 °C identificated as gray color, and higher 30 °C identificated as white color. Finally, the distribution of classified temperature was achieved and used for predicting the potential of the geothermal energy as shown in Fig. 4. Thus, it was verified that calculated temperature from thermal infrared image could be predicting the geothermal resources area and could be used as a reference on exploitation.

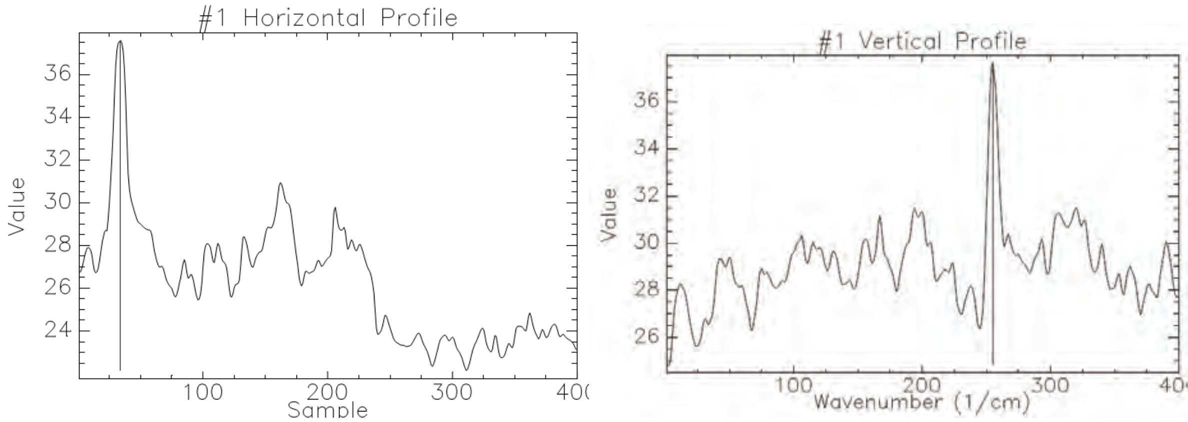
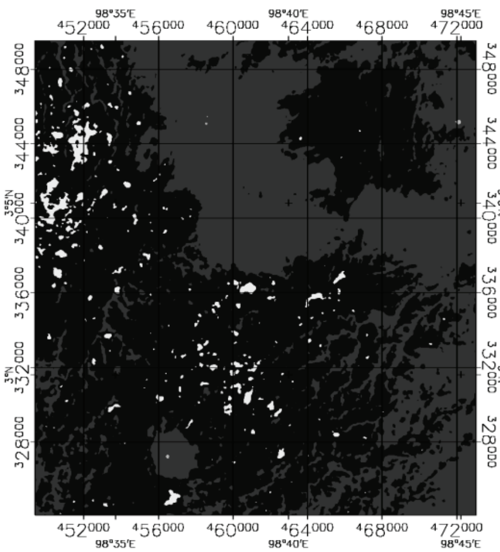


FIGURE 3. Horizontal and vertical profile of the predated point of geothermal resource



Temperature	**Color**	**Classification**
< 20 °C	Black	Low
20 – 25 °C	Ash Gray	Moderate
25 – 30 °C	Gray	High
>30 °C	White	Very High

FIGURE 4. Classification of LST

CONCLUSION

The identification of geothermal resources was successfully found utilize the thermal infrared remote sensing method provided the Land Surface Temperature of Landsat 8 published on February 8th 2015 and June 29th 2015. The maximum value of LST for data of February 8th 2015 was 36.303497 °C and minimum value was 2.720490 °C. The maximum value of LST for the received data of June 29th 2015 was 37.889587 °C and minimum value was 18.476654 °C. Thus it was concluded that the location of research areas in the village Dolok Merawa was potentially for geothermal energy resource and this result can be used as a reference for further exploitation of geothermal.

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